Impacts of microeconomic uncertainty shocks on the aggregate economy: an analysis for Brazil

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Área 4 - Macroeconomia, Economia Monetária e Finanças

Resumo

O objetivo deste trabalho é estimar um modelo de equilíbrio geral dinâmico estocástico (DSGE) para avaliar o impacto de choques de incerteza de ordem microeconômica no Brasil. Estes choques se caracterizam pela interação de um grande número de agentes empreendedores com o setor financeiro. Calibrando o modelo com dados trimestrais da economia brasileira de 2003 à 2017, os resultados apontam que custos de agência nessa relação impactam o crescimento econômico, a formação de capital e o bem-estar das famílias.
Palavras-chave: Incerteza, volatilidade, crescimento, desenvolvimento. **Códigos JEL**: O16, O33, E32.

Abstract

This work aims to estimate a dynamic stochastic general equilibrium model (DSGE) to evaluate the impact of microeconomic uncertainty shocks in the Brazilian economy. The microeconomic shocks emerge from the interaction with a continuum of entrepreneur agents and the financial sector. Calibrating the model using quarterly data from 2003 to 2017, we find that agency costs in the entrepreneurial and financial sector impact economic growth, capital accumulation and household's welfare.
Keywords: Uncertainty, volatility, growth, development. **JEL Codes**: O16, O33, E32.

1 Introduction

This is a research in the field of macroeconomics that aims to provide a deeper understanding of economic uncertainty in Brazil. This work addresses the question of the importance of microeconomic uncertainty shocks in the Brazilian economy. Macroeconomists gained interest and acquired a deeper understanding of the role of firms and individuals in the performance of economies, and nowadays microeconomic elements are increasingly ubiquitous in structural and dynamic macroeconomic models. In example, microeconomic elements can be inserted in such models in form of a large number of firms or agents (instead of a single, representative agent) that need not be homogeneous, interacting in competitive or monopolistic markets. The result of the aggregate economy will emerge from market clearing and other equilibrium conditions. This strategy turns possible to answer more intricate questions in economic policy, without leaving the general equilibrium framework.

More than investigating the impacts of microeconomic shocks itself, we turn our attention to microeconomic uncertainty shocks. In this work, following the existing literature, we interpret such shocks as perturbations to the firms' expectation about the return of their investments. In other terms, think of a statistical distribution of firm outputs: rather than shocks to the mean, this work focuses on shocks to the standard deviation of the distribution. In reality, the production decision of firms can be affected by a multitude of

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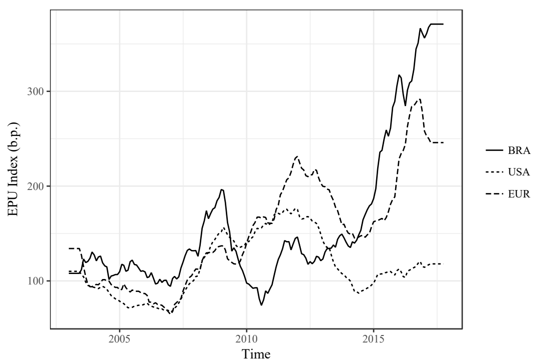
factors: economic, administrative, political. In our model economy, firms respond to fluctuations in own idiosyncratic shocks, macroeconomic policy shocks, input prices and loan interest rates.

Recent work in the real business cycle theory (JUSTINIANO; PRIMICERI, 2008; BORN; PFEIFER, 2014) focuses on time-varying dispersion effects in aggregate variables, and findings from Christiano, Motto and Rostagno (2014) suggest that microeconomic uncertainty shocks are as important as the traditional technology and policy shocks as a source of business cycle fluctuations, meaning that such elements must be incorporated in dynamic stochastic general equilibrium (DSGE) models used by policy makers. In this work, we will focus on microeconomic shocks as a source of economic growth uncertainty. This research departs from the view that evaluate how the standard economic policy shocks affect business cycles. In the context of DSGE models, microeconomic uncertainty shocks are introduced by adding agents or firms that face uncertainty about their output, and such uncertainty need not show strong correlation with the usual aggregate total factor productivity (TFP) shocks, and we follow this definition.

Empirical evidence on the subject is largely devoted to the United States economy. The matter of economic uncertainty received greater attention since the work of Lucas (1988). Beginning in the mid 1980's, the U.S. economy began to experience a phenomenon called the Great Moderation, which was an abrupt decline in the volatility of gross domestic product growth. The causes of the Great Moderation were at the center of a long debate, and Stock and Watson (2003) argue that while efficient monetary policy helped diminish output volatility, about half of the reduction in volatility remained unexplained. One of the purposes of this work is to bring this knowledge to discuss symptoms and causes of economic uncertainty in Brazil.

Figure 1 presents the Economic Policy Uncertainty [1] monthly index, proposed by Baker, Bloom and Davis (2013), from January 1990 to October 2017. Moving averages were calculated to smooth out the series, using a 12-month window. Data shows the effects of 2008 financial crisis, political turmoils and a recent comparison between Brazil, U.S. and European countries. The index is based on political news coverage, stock market fluctuations and disagreements among forecasters about future economic growth. While the index is not a direct proxy for microeconomic uncertainty, it gives an overview of instabilities faced by the economies. Data shows the effects of the 2008 financial crisis and recent political turmoils, in all sets of countries examined (impeachment and economic recession in Brazil, the latest elections in the U.S., Brexit in Europe).

Figure 1 – Moving averages of EPU Index, 1990 - 2017.



Source: The authors, based on methodology from Baker, Bloom and Davis (2013).

The matter of economic uncertainty gained momentum on the macroeconomics research agenda, in the last ten years, due to the latest financial crisis. As noted by Castro (2016, p. 4), in the aftermath of the crisis, Brazil "adopted a new regime, with public banks stepping in strongly in the credit markets to offset the retraction in private banks' credit origination". Some of the findings in the literature and lessons learned from recent financial crises materialized in the form of macroprudential policies and regulations,

[1] Available at: <http://www.policyuncertainty.com/>. Accessed in Nov. 21, 2017.

such as capital controls, corporate governance in firms and restrictions on banking instruments such as credit default swaps (i.e., the Dodd-Frank Act in the United States)[2]. Recently, the literature on economic uncertainty advanced when studies turned their attentions to two facts. First, beyond many analyses on aggregate GDP growth volatility, researchers started looking at the microeconomic level. This includes sector and firm-level data.

2 Theoretical reference

The real business cycles literature emphasizes the role of fluctuations in key macroeconomic variables for economic growth and development, such as government spending, taxation, interest and inflation rates. Also, the role of technological progress and human capital have been widely discussed. Since the seminal work of Kydland and Prescott (1982), the framework has been refined, with the addition of consumption habits, investment adjustment costs, different fiscal and monetary policy rules.

Recently, the role of uncertainty in economic activity has received greater attention (BLOOM, 2014; BAKER; BLOOM; DAVIS, 2013). The development of more sophisticated estimation techniques (such as Bayesian methods) made it possible to study the dynamic behavior of economic variables not only in its first but also second moments. Despite the mixed evidence on the issue of volatility-growth correlation, one of the goals of policy makers is to smooth out deviations from long-term, sustainable economic growth (i.e. monetary policy rules). This research agenda is especially relevant for emerging economies such as Brazil, because the business cycles are more volatile.

In the baseline real business cycles models, financial markets are set aside, with the underlying assumption that financial fluctuations do not affect real economic aggregates. However, Bernanke, Gertler and Gilchrist (1999) point out that, in fact, credit market shocks are not only a consequence but can also cause stress in the real economy. Evidence coming from the financial crises in the 1990's (Southeast Asian Tigers, Russia, Latin American countries) helped popularize this element in small and medium-sized models. Hence, our theoretical approach embodies the strand of the macroeconomic literature of dynamic stochastic general equilibrium models including financial sector as a source (or amplifier) of business cycles.

While there is, to the best of our knowledge, no evidence with respect to microeconomic uncertainty shocks, as we specified, for the Brazilian economy, there is evidence for the impact of financial frictions on Brazil's business cycles, which is the key transmission mechanism of entrepreneurial uncertainty. With a model based on Gerali et al. (2010), Aranha (2012) finds important evidence for Brazil: (i) a reduction in credit market frictions (measured by bank spreads and adjustment costs) results in an increase in investment, consumption and GDP; and (ii) while those frictions help keeping banking spreads high, they have a negative impact on inflation rates. Kanczuk (2013) extends the Smets and Wouters (2007) model, incorporating credit markets for households and firms, to show how macroprudential policies can affect the Brazilian economy. Castro (2016) also focused on the topic, with a model that combines financial frictions and foreign capital flows, that is, direct investment as dependent of sovereign risk, to establish if fiscal policy should react to credit cycles. The authors suggest that this is only the case if macroprudential policies are independent and counter-cyclical.

Now, we discuss microeconomic shocks as a source of business cycles. This hypothesis states that shocks in productivity or sales, at firm or sector level, lead to aggregate output fluctuations, providing a microeconomic foundation to the real business cycles. However, this argument departs from the assumption that aggregate shocks are the result of an average of identical firms or sectors. In fact, empirical evidence from Gabaix and Society (2011), studying the U.S. economy, shows that the distribution of firm sizes is skewed. Hence, exogenous shocks to large firms should account for a non-negligible amount of the business cycles. The author calls it the "granular hypothesis". This is a potential evidence for developing

[2] Available at: <https://www.sec.gov/about/laws/wallstreetreform-cpa.pdf>. Accessed in Apr 15, 2018.

countries, as anecdotal evidence suggests that such economies have greater sectoral concentration, so one could expect this hypothesis to have greater explanatory power.

Acemoglu et al. (2012) refine the previous argument. The authors argue that microeconomic shocks lead to aggregate fluctuations through input-output relationships. This happens because productivity gains propagate along supply chains and generate spillovers to the whole economy. We call it the "network hypothesis". The hypothesis, corroborated by the authors using U.S. input-output data, also states that microeconomic shocks translate into aggregate volatility "if there are significant asymmetries in the roles that sectors play as direct or indirect suppliers to others" (ACEMOGLU et al., 2012, p. 2004). Both the granular and the network hypotheses interact in the sense that large firms and markets have an important contribution to the business cycles. More papers emphasize the network characteristic of modern economies as a transmitter of economic fluctuations. Carvalho (2014) study the production networks using U.S. input-output data and shows that indeed the productivity in central sectors of the economy and GDP growth are strongly correlated. These "central" sectors act like hubs: they provide simple inputs (e.g.: raw materials) that firms from other sectors can resort to, in the event of a break in supply chains.

2.1 The role of finance

Bernanke and Gertler (1995) summarize how credit markets can amplify effects of monetary policy. The external finance premium is the difference between raising capital from internal (reinvesting profits) and external (i.e; equity markets) sources.

This premium, which is counter-cyclical, can be affected via two channels. First, the balance sheet channel: if entrepreneurs have greater net worth, they can self-finance investment projects partially or completely, or offer a higher amount of collateral as a guarantee, diminishing the external finance premium. Thus, the financial position of borrowers should affect the premium. Also, consider the position of borrowers *after* loan contracts are celebrated. If loans are negotiated at current, post-fixed interest rates, monetary policy shocks affect the firms balance sheets in the short term. Now, firms reconsider taking new loans, expanding the external finance premium and depressing investment. Via this mechanism, policy shocks may have long-term effects.

Second, the bank lending channel predicts that banks will also experience a balance sheet effect in response to interest rate adjustments. According to Bernanke and Gertler (1995), while the plausibility of the balance sheet channel is well understood, the bank lending channel is controversial, because financial liberalization can diminish bank lending channel effects, as banks can offer new, less insured products.

Economic policy uncertainty can also influence business cycles. Chi and Li (2017) analyze the impact of swings in economic policy uncertainty on banks loans in China. They regress loan amounts on an economic policy uncertainty index and banking sector controls, concluding that greater policy uncertainty causes a reduction in quantity and size of loans, as they perceive increased risk, and this result is more pronounced in financially less-developed areas. Moreover, the effect is, as expected, different if banks are private, state-owned or have mixed ownership. As a policy recommendation, they advocate for better coordination between commercial banks and the monetary policy authority as a means of smoothing credit supply. Valencia (2017) also shows that, in moments of greater uncertainty, banks adjust their capital-to-assets ratio, which varies according to the bank size, presenting a mechanism of self-insurance. This suggests that, in aggregate terms, the impact of this channel, depends on the relevance of small and big banks. And how does the structure of the banking sector affect economic fluctuations? Larrain (2006) finds that greater access to banks contributes to a reduction in the volatility of industrial production: firms incur short-term loans to smooth output, in response to demand and inventory shocks. Thus, banks have a counter-cyclical effect on uncertainty shocks. Huang, Fang and Miller (2014) show that a highly concentrated banking market correlates with greater industrial growth volatility. However, a more concentrated banking sector can be beneficial to sectors highly dependent on external liquidity. Furthermore, Fendoğlu and Fendo (2017) finds that in emerging countries monetary policy tools based on domestic reserve requirements are helpful to counterbalance foreign capital inflows, and therefore preferred by the economic policy authorities.

In the context of DSGE models, examples of uncertainty/risk as discussed by Pindyck (1991) are explicit in time-to-build models (KYDLAND; PRESCOTT, 1982; JUNG, 2013). In this class of models, a representative agent commits to an investment project that matures many periods ahead. A result supported by the literature is that the longer the "time to build" an investment project, the more uncertain it is, and larger spreads of the investment rate of return with respect to the risk-free rates are required. This is aggravated if there are costs to stop and restart projects. Also, as pointed out by the author, a decrease in interest rates need not benefit long-term investments, because it also reduces capital costs for other projects.

In turn, Aiyagari (1994) focus on a precautionary savings motive, combined with borrowing constraints. The author presents an example model where a continuum of agents are subject to random labor endowment shocks. In this case, uncertainty emerges from the productive process. Because markets are incomplete and agents try to smooth consumption, they accumulate capital. Thus, in face of greater uncertainty agents increase aggregate savings (which we interpret as investment, because of the macroeconomic identity). The author points that earlier studies relied on the pure bequest motive as an explanation to inter-generational capital accumulation, but precautionary savings presents as a relevant explanation, with emphasis on lower income households.

In a survey of U.S. and German firms, Elstner et al. (2012) find that uncertainty proxies based on survey data account for a greater share of output volatility than stock market based proxies. Also, they present interesting evidence: both countries exhibit slightly different output dynamics in response to an uncertainty shock. While in the U.S. shocks have high persistence, in Germany shocks have a pattern of decline followed by quick recovery, called by the authors a "bust-boom cycle". According to the Elstner et al. (2012) and Bachmann and Bayer (2013), this provides evidence of slightly higher cost of factor adjustments, that is, in moments of greater uncertainty firms prefer to postpone investments and observe the behavior of their competitors. Overall, the works of Bachmann suggests that in these countries the effects of "wait-and-see" dynamics on firm-level risk are small. However, the presence of labor regulations and capital constraints in Brazil result in greater factor adjustment costs (in comparison to developed economies). This suggests that investment dynamics and "wait-and-see" behavior could provide a sound theoretical argument to explain some of the effects of microeconomic uncertainty shocks in the Brazilian economy.

The microeconomic uncertainty shocks we will discuss in this work are closely related to the ability of entrepreneurs to thrive. Therefore, we must discuss the ease of doing business in Brazil. In general, while Brazil supports a free enterprise economy, there is extensive government intervention and regulation, which manifests in the form of: (i) permits and obligations with federal, state and municipality entities; (ii) an extensive tax code that firms must comply with. According to the World Bank's 2017 *Ease of Doing Business* index, Brazil is ranked at 123rd place, among 190 countries in the sample. Brazil is poorly ranked especially when it comes to starting a business, paying taxes and dealing with foreign trade. We expect that these difficulties affect both the expected rate of survival of small business ventures and their variability, because entrepreneurs must evaluate both the macroeconomic expectations and immediate obligations when starting a business.

2.2 Discussion of microeconomic uncertainty shocks

In this section we will discuss the origins of microeconomic uncertainty shocks. First, we will discuss what are the conditions that favour the emergence of such shocks. microeconomic uncertainty shocks are commonly attributed to heterogeneities in firms' productive processes and outcomes, that are subject to fluctuations. It is known that credit market imperfections exist, and they can amplify the effect of the uncertainty shocks in the aggregate economy (GERTLER; KIYOTAKI, 2010) due to an information problem, because lenders do not observe the realized shock from borrowers. This phenomenon is called the "costly state verification problem" (TOWNSEND, 1979). This is an essential theoretical element, because in the absence of credit constraints, there is no wedge in banks' zero profit condition, providing us evidence that any proxy variable for microeconomic uncertainty shocks must be correlated with financial markets (and not exogenously in production, in example).

The proxy for microeconomic uncertainty shocks should contain a few important properties. First, is must be counter-cyclical, according to empirical evidence (BAKER; BLOOM; DAVIS, 2013). Second, according to Cesa-Bianchi and Fernandez-Corugedo (2014), the proxy should be able to indirectly generate fluctuations aggregate in output, consumption, investment and labor, based on evidence from Christiano, Motto and Rostagno (2014). Having all that said, it is admittedly difficult to obtain a definitive measure of economic uncertainty: firstly because it derives from a multitude of factors, such as economic conditions, agents' perception and behavior, and secondly because it is necessary to adopt some definition of uncertainty, and any choice may lead to different strands of literature and empirical results. Also, there are empirical limitations. According to Ludvigson, Ma and Ng (2015, p. 16), "common uncertainty proxies contain economically large components of their variability that do not appear to be generated by a movement in genuine uncertainty across the broader economy". We stick to the knightian definition of uncertainty, namely the difficulty of agents to forecast the probability of occurrence of all possible outcomes from a set of events (and histories).

The works of Nicholas Bloom investigate the relationship between uncertainty and economic performance in greater detail. An important remark of the author is that "(...) uncertainty also appears to endogenously increase during recessions, as lower economic growth induces greater micro and macro uncertainty" (BLOOM, 2014, p. 153). Studying the U.S. economy, Bloom (2014) defines stylized facts for economic uncertainty: (i) macroeconomic uncertainty rises in recessions. That is, the volatility of almost all key economic indicators rises in recessions; (ii) microeconomic uncertainty also rises in recessions. The author states this fact based on data from firms and industrial production. Volatility rises in the sense that – in more uncertain times – some sectors go better than others. Bloom (2014) also points out that this facts are not restricted to the U.S. economy, as the same economic rationale is also found in global economies, and impacts are even more intense in developing countries such as Brazil.

Now, we present each of the proposed measures of microeconomic uncertainty, drawing from the literature, to a posterior comparison. All time series are seasonally adjusted, and first differences are taken at any sign of unit roots.

Uncertainty evaluation based on the productivity of firms is the most commonly found in the literature (ELSTNER et al., 2012; CHUGH, 2013; CHRISTIANO; IKEDA, 2013; CHRISTIANO; MOTTO; ROSTAGNO, 2014). It is a known fact that the distribution of firm sales changes from times of economic growth to recessions, as the average goes down and the dispersion goes up (BLOOM, 2014). Publicly available firm-level data of private companies in Brazil are scarce. As a proxy variable, we use the moving standard deviation of monthly industry sales in the state of São Paulo, produced by FIESP (*Federação das Indústrias do Estado de São Paulo*).

Since economic uncertainty is understood as a result of multiple factors, some authors and entities proposed composite indices that can be used as a proxy for microeconomic uncertainty shocks. First, we consider the Economic Policy Uncertainty[3] (EPU) monthly index, proposed by Baker, Bloom and Davis (2013). The index is based on political news coverage, stock market fluctuations and disagreements among forecasters about future economic growth. The index have interesting properties: first, the selection of news coverage is statistically resistant to "media political bias". This was tested by comparing two subsamples of newspapers segregated by political orientation. While the EPU index is primarily oriented to measure economic policy uncertainty (that is, shifts in fiscal and monetary policy) that refers to macroeconomic uncertainty, it contains useful elements for the study of microeconomic uncertainty shocks.

In Brazil, there is a similar effort, namely the IIE-Br (*Índice de Incerteza Econômica*) index, developed by IBRE/FGV. In a similar manner to Baker, Bloom and Davis (2013), the IIE-Br index is a weighted average of three components:

$$IIE_t = 0.7 * IIE_{\text{media}} + 0.2 * IIE_{\text{expectations}} + 0.1 * IIE_{\text{market}} \tag{1}$$

3 Available at: <http://www.policyuncertainty.com/>.

IIE_{media} is based on the frequency of news mentioning keywords such as "uncertainty", "crisis", "risk" in Brazilian main newspapers[4]; $IIE_{\text{expectations}}$ is built upon measures of disagreement among forecasters with respect to exchange and inflation rates (data available in Brazilian Central Bank FOCUS reports) and IIE_{market} is based on the volatility of Ibovespa, the Brazilian stock market index. The IIE-Br index is standardized such that it has mean 100 and standard deviation 10 in the last ten years.

3 Analytical model

To evaluate the role of microeconomic uncertainty shocks in business cycles in Brazil, we present a dynamic stochastic general equilibrium model based on Dorofeenko, Lee and Salyer (2008). This is a model of a closed economy with a financial sector based on Carlstrom and Fuerst (1997). The key actors of the model are the *entrepreneurs*, which produce finished capital goods and are subject to production uncertainty and interact with banks to finance their activities. This interaction between entrepreneurs and banks will be the source of shocks that emerge from the financial sector and affect the real economy. Equity markets are absent from the modeled financial sector, hence debt is the only source of external finance. We enhance the model by adding fiscal and monetary policy, in order to evaluate the impacts of economic policy shocks in our model economy. The main variable of interest is S_t, the time-varying standard deviation of microeconomic uncertainty shocks. Innovations to S_t allow for the dispersion of the shocks to change over time. The fundamentals of this model resemble a standard real business cycles (RBC) model, with the addition of financial market imperfections. The model incorporates the idea of the "financial accelerator", which brings the external finance premium to investment dynamics. The relationship between entrepreneurs and banks are the key aspect behind microeconomic uncertainty shocks. Also, the financial accelerator described above depends on costly state verification, that introduces information asymmetries between financial parties.

An overview of the model follows. Figure 2 shows all the interactions between agents, in terms of the flows of inputs, outputs and goods. In the center of the diagram are the agents directly involved in the financial frictions, that according to the theoretical framework amplify the microeconomic uncertainty shocks throughout the economy. There is a continuum of agents distributed in the $(0,1)$ interval, divided between households and entrepreneurs. Entrepreneurs represent a fraction η of the economy, while households represent a fraction $1-\eta$. To finance their activities, they interact with financial intermediaries called capital mutual funds (CMF) in Carlstrom and Fuerst (1997), which in here we simply refer as banks. In addition, there are firms that employ capital, household and entrepreneurial labor to produce a final, homogeneous good, and their productivity is subject to exogenous shocks.

Here, we define the financial contract and its optimal conditions. We follow the specification of the contract in Dorofeenko, Lee and Salyer (2008). Financial contracts are one-period loans celebrated by two parties:

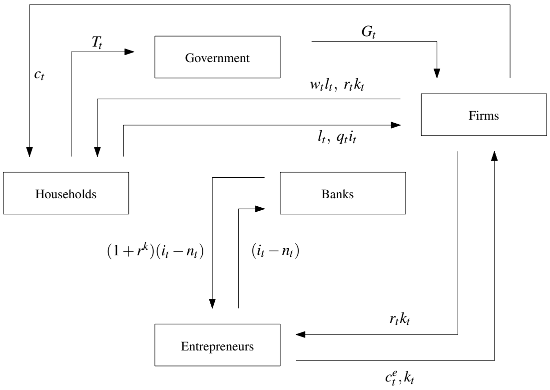
- *Entrepreneurs*: Risk-neutral agents that finance investment project combining internal (their own net worth) and external (loans from banks) resources.

- *Banks*: Risk-neutral financial intermediaries that operate in perfect competition. Banks collect resources from entrepreneurs when they: (i) go bankrupt; (ii) repay loans and (iii) buy capital from entrepreneurs willing to increase consumption.

In every period, entrepreneurial productivity is subject to an exogenous shock ω_t. The realization of this shock at time t is known only by entrepreneurs – banks must pay a fraction μ of the investment to observe the entrepreneurs' productivity. That is, they invest an amount i_t in capital goods with an expected return of $\omega_t i_t$. This productivity shock follows a log-normal distribution with mean one: $\omega_t \sim \log\mathcal{N}(1,S_t)$.

[4] The full text in *Folha de São Paulo* and *Valor Econômico* is analyzed. In the other selected newspapers (*O Globo, Estado de São Paulo, Correio Braziliense* and *Zero Hora*), data is collected in the publications' Twitter accounts.

Figure 2 – Diagram of flows in the model



Source: The author.

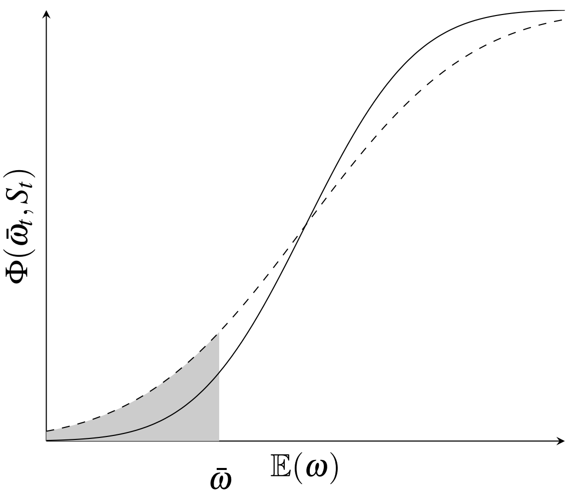
Following the literature, we define the time-varying dispersion of entrepreneurial productivity S_t as a first-order autoregressive process:

$$S_t = \bar{S}_t^{1-\zeta} S_{t-1}^{\zeta} \varepsilon_t^S \tag{2}$$

where $\varepsilon_t^S \sim N(0,1)$ is the *microeconomic uncertainty shock*.

Figure 3 provides intuition on the microeconomic uncertainty shock. The solid line is the initial *cumulative distribution function* (c.d.f.) of ω_t, while the dashed line is the c.d.f after a positive shock in u_t. Shocks to the dispersion of entrepreneurial productivity, although mean-preserving, increase uncertainty about entrepreneurs' productivity, thus increasing the probability of bankruptcy $\Phi(\omega, S_t)$ (which will be later defined) and changing the conditions of the financial contract:

Figure 3 – Effect of a microeconomic uncertainty shock



Source: The author.

An entrepreneur has one unit of labor that is always supplied and z_t units of capital at time t. Capital can be rented to firms at a rate of return r_t. Hence, entrepreneurial income is $n_t + r_t z_t$. Also accounting for capital depreciation, net worth at time t is defined by the equation:

$$n_t = w_t + z_t(r_t + q_t(1-\delta)) \tag{3}$$

A solvent (i.e., $n_t > 0$) entrepreneur borrows $i_t - n_t$ consumption goods from banks, with an obligation to pay back $(1+r_t^k)(i_t - n_t)$, where $r_t^k > r_t \ \forall t$ is the loan rate. According to their production, there will be a threshold shock $\bar{\omega}_t$ that separates bankrupt from non-bankrupt entrepreneurs:

$$\omega_t < \frac{(1+r^k)(i_t - n_t)}{i_t} \equiv \bar{\omega}_t \tag{4}$$

This leads us to two possible scenarios:

1. $\omega_t \geq \bar{\omega}_t$: The entrepreneur produces $\omega_t i_t$ units of capital and pays back $(1+r^k)(i_t - n_t)$ to banks.
2. $\omega_t < \bar{\omega}_t$: The entrepreneur goes bankrupt and the bank will take all assets, upon facing monitoring costs μ.

We should now define the shared of capital production to be distributed to entrepreneurs and banks:

$$f(\bar{\omega}_t, S_t) = \int_{\bar{\omega}_t}^{\infty} \omega \phi(\bar{\omega}_t, S_t) d\omega - [1 - \Phi(\bar{\omega}_t, S_t)]\bar{\omega}_t \tag{5}$$

$$m(\bar{\omega}_t, S_t) = \int_{-\infty}^{\bar{\omega}_t} \omega \phi(\bar{\omega}_t, S_t) d\omega + [1 - \Phi(\bar{\omega}_t, S_t)]\bar{\omega}_t - \mu \Phi(\bar{\omega}_t, S_t) \tag{6}$$

where $f(\bar{\omega}_t, S_t)$ is the share of capital output obtained by the entrepreneur and $m(\bar{\omega}_t, S_t)$ is the share received by banks. Note the integrands: while $f(\bar{\omega}_t, S_t)$ is calculated above the threshold shock, $m(\bar{\omega}_t, S_t)$ is calculated below the shock. We also have the property that $f(\bar{\omega}_t, S_t) + m(\bar{\omega}_t, S_t) = 1 - \mu \Phi(\bar{\omega}_t, S_t)$.

The optimal financial contract is a choice of investment and a threshold productivity shock that gives the entrepreneur maximum return, once banks are willing to offer such resources (an incentive compatibility constraint). Defining $\Phi(\bar{\omega}_t, S_t)$ as the cumulative distribution function of ω_t and $\phi(\bar{\omega}_t, S_t)$ as its probability distribution function, the optimal contract is the solution to the optimization problem:

$$\max_{\{i_t, \bar{\omega}_t\}} q_t i_t f(\bar{\omega}_t, S_t) \tag{7}$$

$$\text{s.t. } q_t i_t m(\bar{\omega}_t, S_t) \geq i_t - n_t \quad \forall t \tag{8}$$

Solution of the problem above leads to the following first order conditions:

$$\frac{\partial L}{\partial \bar{\omega}} : q_t i_t \frac{\partial f(\bar{\omega}_t, S_t)}{\partial \bar{\omega}} = -\lambda_t q_t i_t \frac{\partial m(\bar{\omega}_t, S_t)}{\partial \bar{\omega}} \tag{9}$$

$$\frac{\partial L}{\partial i_t} : q_t f(\bar{\omega}_t, S_t) = -\lambda_t [1 - q_t m(\bar{\omega}_t, S_t)] \tag{10}$$

The first condition can be rewritten as:

$$1 - \frac{1}{\lambda_t} = \frac{\phi(\bar{\omega}_t, S_t)}{1 - \Phi(\bar{\omega}_t, S_t)} \tag{11}$$

Solving for λ_t and plugging into the second condition, we can find an expression for q_t:

$$\begin{aligned} \frac{1}{q_t} &= \left[(f(\bar{\omega}_t, S_t) + m(\bar{\omega}_t, S_t)) + \frac{\phi(\bar{\omega}_t, S_t)\mu f(\bar{\omega}_t, S_t)}{\frac{\partial f(\bar{\omega}_t, S_t)}{\partial \bar{\omega}}} \right] \\ &= \left[1 - \mu \Phi(\bar{\omega}_t, S_t) + \frac{\phi(\bar{\omega}_t, S_t)\mu f(\bar{\omega}_t, S_t)}{\frac{\partial f(\bar{\omega}_t, S_t)}{\partial \bar{\omega}}} \right] \end{aligned} \tag{12}$$

The second equilibrium condition can also be rewritten as:

$$i_t = \frac{1}{1 - q_t m(\bar{\omega}_t, S_t)} n_t \tag{13}$$

Let's examine the properties of this investment model. We can interpret Equation 13 as the aggregate investment supply function, decreasing in the price of capital q_t and increasing in net worth n_t, while $\bar{\omega}_t$ is uniquely defined by Equation 12, once we set $\bar{\omega}_t$ and S_t as fixed in our comparative statics exercise. Since Equation 13 is linear in its arguments, simple aggregation is possible. To answer how microeconomic uncertainty shocks affect investment demand, note that in Equation 13 a rise in $\bar{\omega}_t$ implies a rise in $m(\bar{\omega}_t, S_t)$, leading to a fall in i_t, *ceteris paribus*.

Now, we move on to a detailed description of the agents of the model. Households are risk-neutral and have infinite life. They interact with firms by selling labor (in exchange of wages w_t) and renting capital (at a rate r_t). Following Dorofeenko, Lee and Salyer (2008), we choose a simple quasi-linear functional form for household utility. Households maximize the discounted sum of lifetime expected utility, by choosing the sequence of allocations of the final consumption good and leisure $\{c_t, l_t\}_{t=0}^{\infty}$ starting from the information set at time $t = 0$, according to the problem:

$$\max_{\{c_t, l_t\}_{t=0}^{\infty}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t [\ln(c_t) + \nu(1 - l_t)] \tag{14}$$

$$\text{s.t. } w_t l_t + r_t k_t \geq c_t + q_t i_t + T_t \quad \forall t \tag{15}$$

$$k_{t+1} = (1 - \delta) k_t + i_t \quad \forall t \tag{16}$$

where $\beta \in (0,1)$ is the discount factor, ν is the elasticity of labor, w_t is the real wage, r_t is the capital rental rate and k_t is the capital stock, q_t is the price of capital goods, i_t is the flow of new capital goods and T_t are lump-sum transfers to the government. The price of the final consumption good is normalized to unity. The second constraint is a standard law of motion for the households' capital stock, with a depreciation rate $\delta \in (0,1)$. To solve the constrained optimization problem above, we plug the second constraint into the first and form a Lagrangian. The first order conditions are:

$$\nu c_t = w_t \tag{17}$$

$$\frac{q_t}{c_t} = \beta \mathbb{E}_t \left[\frac{q_{t+1}(1 - \delta) + r_{t+1}}{c_{t+1}} \right] \tag{18}$$

The resulting equilibrium gives relationships that are standard in the literature of RBC models: the first condition states that the marginal rate of substitution between leisure and consumption equals real wages, while the second is the Euler equation, that describes household consumption dynamics.

Firms combine capital, household and entrepreneurial labor to produce the final consumption good, using a constant returns-to-scale Cobb-Douglas technology according to the equation:

$$Y_t = A_t F(K_t, H_t, H_t^e) = A_t K_t^{\alpha_K} H_t^{\alpha_H} (H_t^e)^{1 - \alpha_K - \alpha_H} \tag{19}$$

Total factor productivity (TFP) evolves according to a first-order autoregressive process in logarithms:

$$A_{t+1} = A_t^{\rho} \varepsilon_{t+1}^{A} \tag{20}$$

where ρ_t is the persistence of TFP shocks, and ε_{t+1}^{A} is an i.i.d shock that follows a standard normal distribution. Equilibrium conditions of firms are found by maximizing production subject to households' input supply:

$$w_t = \alpha_H \frac{Y_t}{H_t} \tag{21}$$

$$r_t = \alpha_K \frac{Y_t}{K_t} \tag{22}$$

$$w_t^e = (1 - \alpha_K - \alpha_H) \frac{Y_t}{H_t^e} \tag{23}$$

where A_t is total factor productivity, K_t is the capital stock, H_t[5] is aggregate household labor supply and H_t^e is entrepreneurial labor supply at time t. According to equations above, wages and the capital rental rate should equal their marginal rates of transformation in equilibrium.

Entrepreneurs maximize the discounted sum of their lifetime utility, according to the problem below:

$$\max_{\{c_t^e\}_{t=0}^{\infty}} \mathbb{E}_0 \sum_{t=0}^{\infty} (\beta\gamma)^t c_t^e \tag{24}$$

$$\text{s.t. } z_{t+1} = n_t \left[\frac{f(\bar{\omega}_t, S_t)}{1 - q_t m(\bar{\omega}_t, S_t)} \right] - \frac{c_t^e}{q_t} \quad \forall t \tag{25}$$

$$n_t = w_t + z_t(r_t + q_t(1-\delta)) \quad \forall t \tag{3}$$

where $\gamma \in (0,1)$ is an additional discount factor, implying that entrepreneurs are more impatient than households. Entrepreneurs' choice is constrained by the law of motion of capital and definition of net worth, and their consumption is defined after the returns from investment are realized. This is necessary in order to prevent a scenario where entrepreneurs accumulate enough capital to finance their projects entirely with internal resources [6].

Solution of the problem above leads to the following equilibrium condition:

$$q_t = \beta\gamma \mathbb{E}_t \left[(q_{t+1}(1-\delta) + r_{t+1}) \left(\frac{q_{t+1} f(\bar{\omega}_t, S_t)}{1 - q_{t+1} m(\bar{\omega}_t, S_t)} \right) \right] \tag{26}$$

We introduce economic policy in the model, starting with fiscal policy. There is a government that consumes final goods and finance expenditures via lump-sum transfers from households. Hence, ricardian equivalence holds every period. Government consumption follows a first-order autoregressive process:

$$G_t = \bar{G}^{1-\rho^g} G_{t-1}^{\rho^g} + \varepsilon_t^G \tag{27}$$

We introduce the definition of equilibrium with the market clearing conditions. First, the clearing conditions in labor markets, recalling that η is the share of entrepreneurs in the economy, and labor supply $(1 - l_t)$ is normalized to unity:

$$H_t = (1-\eta) l_t \tag{28}$$

$$H^e = \eta \tag{29}$$

Next, the market clearing conditions in the final goods market. The first condition simply states that output equals the sum of aggregate household consumption, invest and government consumption.

$$C_t + I_t + G_t = Y_t \tag{30}$$

$$C_t = (1-\eta) c_t + \eta c_t^e \tag{31}$$

$$I_t = \eta i_t \tag{32}$$

[5] Household labor H_t is linked to the definition of leisure l_t by equation $H_t = (1-\eta) l_t$.

[6] The other way to turn this issue tractable is to assume that a small fraction of entrepreneurs consume all their assets and leave the market in every period. This is observed in Bernanke, Gertler and Gilchrist (1999)

Now, the equilibrium law of motion of capital stock:

$$K_{t+1} = (1-\delta)K_t + I_t[1-\mu\Phi(\bar{\omega}_t, S_t)] \tag{33}$$

A competitive equilibrium is defined by the optimal policy rules from the sequence of variables $\{K_{t+1}, Z_{t+1}, H_t, H_t^e, q_t, n_t, i_t, \bar{\omega}_t, c_t, c_t^e\}$ and states $\{K_t, Z_t, A_t, S_t, g_t\}$ that satisfy the equations discussed earlier. Substitutions that derived from the firms' equilibrium conditions are made when possible. First, the equilibrium conditions that derive from the households' optimization problem:

$$\nu c_t = \alpha_H \frac{Y_t}{H_t} \tag{17}$$

$$\frac{q_t}{c_t} = \beta \mathbb{E}_t \left[\frac{1}{c_{t+1}} \left(q_{t+1}(1-\delta) + \alpha_K \frac{Y_{t+1}}{K_{t+1}} \right) \right] \tag{18}$$

The conditions at the optimal financial contract:

$$q_t = \left[1 - \mu\Phi(\bar{\omega}_t, S_t) + \frac{\phi(\bar{\omega}_t, S_t)\mu f(\bar{\omega}_t, S_t)}{f'(\bar{\omega}_t)} \right]^{-1} \tag{12}$$

$$i_t = \frac{1}{1 - q_t m(\bar{\omega}_t, S_t)} n_t \tag{13}$$

The conditions associated with the entrepreneurs' optimization problem:

$$q_t = \beta\gamma \mathbb{E}_t \left[\left(q_{t+1}(1-\delta) + \alpha_K \frac{Y_{t+1}}{K_{t+1}} \right) \left(\frac{q_{t+1} f(\bar{\omega}_t, S_t)}{1 - q_t m(\bar{\omega}_t, S_t)} \right) \right] \tag{26}$$

$$n_t = \alpha_{H^e} \frac{Y_t}{H_t^e} + Z_t \left(q_t(1-\delta) + \alpha_K \frac{Y_t}{K_t} \right) \tag{3}$$

$$Z_{t+1} = \eta n_t \left[\frac{f(\bar{\omega}_t, S_t)}{1 - q_t m(\bar{\omega}_t, S_t)} \right] - \eta \frac{c_t^e}{q_t} \tag{25}$$

The equilibrium defined by the processes that govern TFP, microeconomic uncertainty and government spending:

$$A_{t+1} = A_t^{\rho} \varepsilon_{t+1}^A \tag{20}$$

$$S_t = \bar{S}^{1-\zeta} S_{t-1}^{\zeta} + \varepsilon_t^S \tag{2}$$

$$G_t = \bar{G}^{1-\rho^g} G_{t-1}^{\rho^g} + \varepsilon_t^G \tag{27}$$

Finally, a definition of household welfare that will be used in further analyses:

$$\mathscr{W}_t = U(c_t, l_t) + \beta \mathbb{E}_t[U(c_{t+1}, l_{t+1})], \tag{34}$$

$$\text{with } U(c_t, l_t) = \ln(c_t) + \nu(1 - l_t)$$

4 Data and procedures

In summary, the model has 10 real variables, 16 parameters, 10 equilibrium equations and 4 exogenous shocks. The time unit of the model is a quarter. In this work, we perform simulations with the aim to approximate actual data, to ensure the robustness of our findings. We used quarterly data from the Brazilian central bank (Time Series Management System, SGS) for macroeconomic aggregates, namely $c_t, c_t^e, i_t, g_t, k_t, h_t$. Consistent, seasonally adjusted quarterly data for the aggregates span from the third quarter of 1993 to present dates. Data on credit market variables are available at the *Relatório de Estabilidade Financeira*[7] reports from the Brazilian central bank, available every semester since 2002. In conformity with other data sources, our period of analysis spans from the first quarter of 2003 to the last quarter of 2017. In the spirit of Baker, Bloom and Davis (2013), we considered and discussed several variables as proxies for economic uncertainty in Section 2, to finally choose a proxy that is based on stock returns.

To perform the simulations, we input the steady state equilibrium equations into Dynare, a toolbox for DSGE models available for MATLAB and Octave. Table 1 provides the list of parameters of the model to be specified and data sources for calibration. To calibrate the model, we used empirical data for our period of interest using the data sources noted above, whenever feasible. Otherwise, we resorted to our main references of analytical models with financial frictions (CARLSTROM; FUERST, 1997; DOROFEENKO; LEE; SALYER, 2008; CHRISTIANO; MOTTO; ROSTAGNO, 2014; CESA-BIANCHI; FERNANDEZ-CORUGEDO, 2014) and the existing literature for DSGE models with financial frictions that study the Brazilian economy (CASTRO et al., 2011; CAVALCANTI; VEREDA, 2011; ARANHA, 2012; KANCZUK, 2013; AREOSA; COELHO, 2015; DIVINO; KORNELIUS, 2015).

We should comment in detail how parameters were retrieved. The discount factor β was calculated as follows: first, we calculated average inflation π and interest rates Rn (annualized SELIC) using data from BACEN, then we applied a relationship found in the canonical real business cycle model:

$$\beta = \frac{\bar{\pi}}{(1+\bar{Rn})} \tag{35}$$

The value found closely matches Carvalho and Castro (2017). For the capital share of production α_K, we follow the literature that sets a value of 0.3 for Brazil (ARANHA, 2012). For the household labor share of production α_H, we set a value of 0.699 to leave a share of 0.001 for the entrepreneurial labor production (defined in the model as $1-\alpha_K-\alpha_H$).

Table 1 – Calibration of model parameters

Param.	Value	Description	Reference
β	0.890	Discount factor	Relative to real interest rates (BACEN)
α^K	0.300	Capital share	Aranha (2012)
α^H	0.699	Household labor share	Relative to α^K
γ	0.870	Entr. discount factor	Carlstrom and Fuerst (1997)
δ	0.005	Depreciation rate	Annual rate of 2%
η	0.100	Share of entrepreneurs	Carlstrom and Fuerst (1997)
ν	2.520	Elast. of household labor	Dorofeenko, Lee and Salyer (2008)
μ	0.300	Monitoring costs	Cesa-Bianchi and Fernandez-Corugedo (2014)
ρ^A	0.996	Persistence of TFP	AR(1) on output gap (BACEN)
σ^A	0.072	Std. dev. of TFP shock	AR(1) residuals on output gap (BACEN)
σ^N	0.100	Std. dev. of net worth shock	Dorofeenko, Lee and Salyer (2008)
ρ^G	0.995	Persistence of govt. spending	AR(1) on govt. consumption (BACEN)
ζ	0.950	Persistence of unc. shock	AR(1) on scaled uncertainty index
$\bar{S}$	0.207	S.s. micro uncertainty	Christiano, Motto and Rostagno (2014)
$\bar{G}$	0.250	S.s. govt. spending	Average $\frac{G_t}{Y_t}$ ratio (BACEN)

Source: The author.

To set the entrepreneurial discount factor γ, we follow Carlstrom and Fuerst (1997). They set this parameter to ensure a rate of return to capital such that entrepreneurs are willing to accumulate capital

[7] Available at: <http://www.bcb.gov.br/publicacoes/ref>.

– considering that they are more impatient than households. The capital depreciation rate δ follows the literature (an annual rate of 2%). Next, we draw some parameters that are specific from this class of models from the literature (η, ν, μ). Here, we draw special attention to the monitoring costs parameter μ: this controls the weight of costly state verification in the optimal contract setting. The values chosen in the literature span from 0.15 to 0.30, when studying developed economies. We opt for higher values to reflect imperfections in developing credit markets.

To calibrate the productivity shocks ρ_A and σ_A, we fit a first-order autoregressive process on GDP deviations from its long-term trend, a common measure of total factor productivity[8]. We also employ this strategy to determine the persistences of fiscal policy and uncertainty shocks. Finally, we get the steady state microeconomic uncertainty $\bar{S}$ from Cesa-Bianchi and Fernandez-Corugedo (2014), while the steady state government spending $\bar{G}$ is obtained by calculating the average government consumption to GDP ratio, using BACEN data.

5 Results

In this Section we will present the outputs of the model simulations. First, we introduce plots of impulse-response functions of the model. The impulse-response analysis describe how our model variables behave upon our exogenous shocks (microeconomic uncertainty shocks, fiscal and monetary policies) in terms of deviations from their steady-state values, up to 40 quarters (10 years) after the shock[9]. Next, we further diagnose the correlation between aggregates to find if they conform to existing literature and empirical data. Finally, we perform a welfare analysis of the household in response to the exogenous shocks to determine possible welfare losses due to microeconomic uncertainty shock.

5.1 Impulse response analysis

For the impulse response analysis, we employ a second-order approximation of policy functions around the non-stochastic steady state, as in Schmitt-Grohé and Uribe (2004). This is necessary as we expect that the effects of microeconomic uncertainty shocks are limited in a first-order approximation as (i) uncertainty shock are mean-preserving; (ii) only one of the possible states of the model economy is considered and (iii) evaluation of welfare functions under first-order approximations are imprecise. This also implies that we require a different treatment of impulse response functions, because in a higher-order approximation we have a multitude of optimal policy functions, according to each of the possible states generated by microeconomic uncertainty shocks at any given time (histories). We also apply the pruning procedure implemented by Andreasen, Fernández-Villaverde and Rubio-Ramírez (2018) to treat impulse response functions that exhibit explosive behavior, a problem commonly found in higher-order approximations. The pruning procedure consists of discarding terms with order greater than the required when computing the approximated solution of the system.

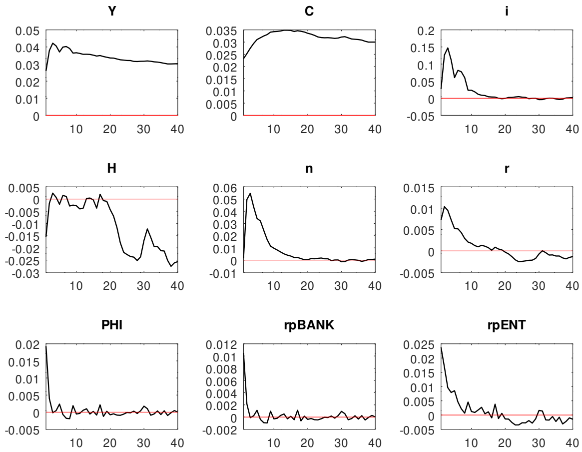
Figure 4 shows the response of the main model variables to a TFP shock. First, we find that impacts to output and household consumption are but long-lasting. Shocks to investment, labor inputs, entrepreneurs' net worth and price of capital exhibit a quicker speed of correction to the steady state. Note the rise in both investment and the price of capital: in the partial equilibrium of capital markets, this indicates a rise in the demand for capital. Variables `PHI`, `rpBANK` and `rpENT` are, respectively, the steady-state probability of default for entrepreneurs $\Phi(\bar{\omega}_t, S_t)$, the risk premiums for banks and entrepreneurs.

In Figure 5 we plot responses to a positive shock to entrepreneurial net worth shock. We observe that all variables quickly return to their steady-state values. As expected, interest rates fall, because en-

[8] An alternative measurement for TFP can be found by extracting the residuals from a least-squares fit of GDP on gross fixed capital formation and labor force.

[9] Plots for government consumption appear only in the impulse responses to fiscal policy shocks, because fiscal expenditures are exogenously determined (according to Equation 27).

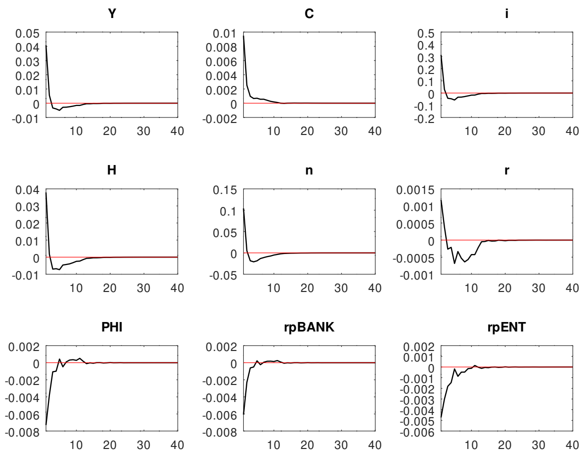
Figure 4 – Responses to a TFP shock



Source: The author.

trepreneurs can finance a greater deal of their projects internally. The demand for external finance falls, causing a fall in the price of capital.

Figure 5 – Responses to a net worth shock



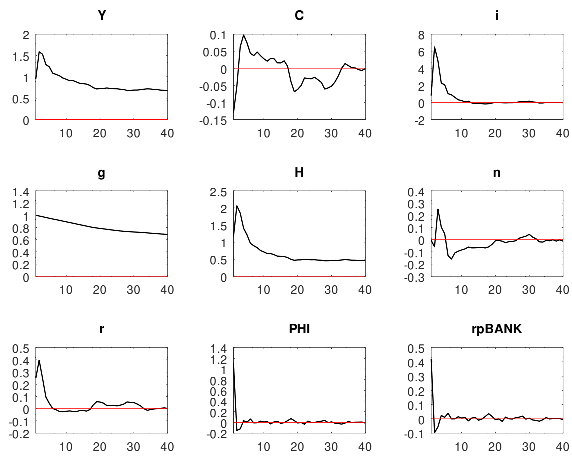
Source: The author.

Figure 6 presents the responses to a positive fiscal policy shock. We observe that a fiscal policy shock induces a rise in output, investment and labor aggregates. This is straightforward as the government is increasing the demand for final goods, hence firms must increase production to clear markets. This increases the demand for capital, explaining the increase in interest rates. Consequently, household consumption decreases following a fiscal policy shock because a larger fraction of final goods are being directed to the government. An interesting result emerges: fiscal stimulus reduces the bankruptcy hazard rate, although the impact is small.

5.2 The role of microeconomic uncertainty shocks

Figure 7 shows the responses of the model variables to a positive (increasing) shock in microeconomic uncertainty, our main exogenous shock of interest. The plots reveal that greater uncertainty diminishes

Figure 6 – Responses to a fiscal policy shock



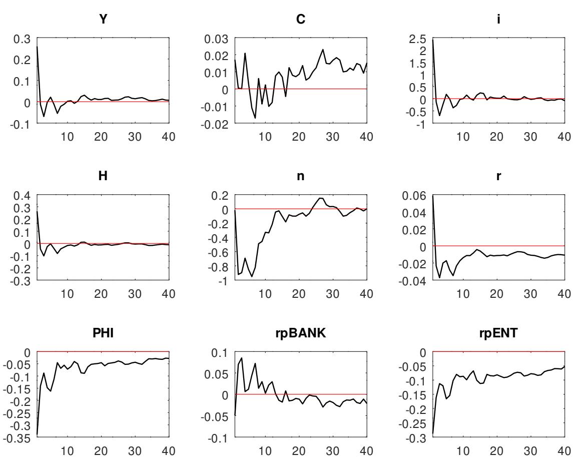
Source: The author.

output and especially investment. Also, we learn that final goods consumption increases: entrepreneurs are more impatient than households, so as investment decreases their optimal decision is to prefer present consumption.

In addition, note that entrepreneurial net worth increases following a microeconomic uncertainty shock, revealing that in times of greater uncertainty entrepreneurs prefer to finance their projects internally in a greater scale. This happens because greater microeconomic uncertainty raises the external finance premium, as predicted by the literature of financial accelerator models.

We also find that aggregate investment decreases, and the price of capital initially responds to uncertainty shocks with a fall, followed by a persistence rise. In the partial equilibrium of capital markets, this is similar to what happens after a TFP shock, but here there is a decline in capital supply.

Figure 7 – Responses to a microeconomic uncertainty shock

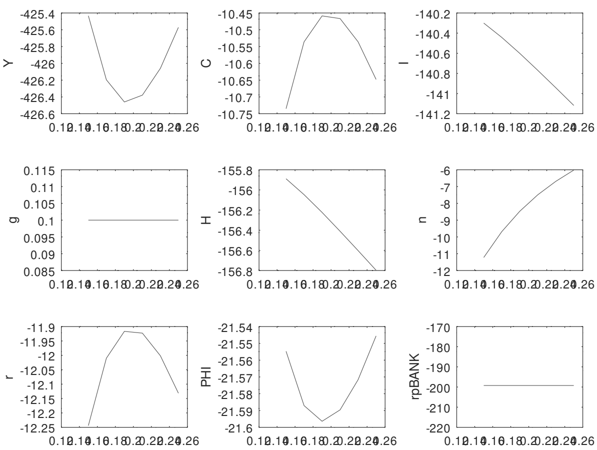


Source: The author.

Now, we follow the insight from Cesa-Bianchi and Fernandez-Corugedo (2014) and analyze how steady state values of macroeconomic aggregates change according to the steady state levels of microeconomic uncertainty. Results are plotted in Figure 8, where the steady state levels of aggregates are in the vertical axes, and steady state levels of microeconomic uncertainty in the horizontal axes, ranging from 0.15 to 0.25 (a reasonable set of values around the steady-state calibrated value $\bar{S}$).

We have found that steady state levels are decreasing in uncertainty, in most economic aggregates. Consumption, investment and labor supply are decreasing, a fact that is predicted by the literature as a precautionary savings mechanism. Entrepreneurial net worth is increasing in uncertainty because of the increasing cost of external finance. Because investment is decreasing, we conclude that entrepreneurs are less leveraged when economic uncertainty is higher. The model also predict that steady state interest rates are lower when steady state levels of microeconomic uncertainty. This result should not be confused with the impacts of microeconomic uncertainty shocks on interest rates, where in fact interest rates go up and then oscillate back to the steady state. Otherwise, we combine this with the evidence that investment levels are decreasing to conclude that in greater steady states of uncertainty, the supply of capital decreases.

Figure 8 – Steady states and microeconomic uncertainty shocks



Source: The author.

5.3 Welfare analysis

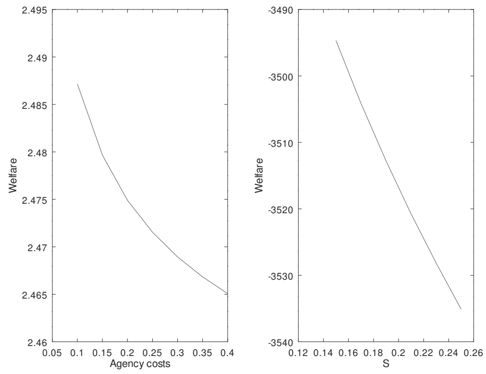
Now, we will comment the effects of agency costs in the welfare of agents, by evaluating Equation 34. In Figure 9 we plot household welfare as a function of agency costs by performing simulations of our model, using different calibrations for the monitoring cost parameter μ, ranging from 0.1 to 0.4 in steps of 0.05, and for the steady state microeconomic uncertainty $\bar{S}$, ranging from 0.15 to 0.25 in steps of 0.05, *ceteris paribus*. Simulations show that, as expected, our model economy face welfare losses emerging from our costly state verification problem. While the fall in welfare due to monitoring costs is exponentially smoothed, the fall due to average uncertainty is approximately linear.

6 Conclusion

The aim of this work was to analyze the impact of microeconomic uncertainty shocks in the Brazilian economy, with the use of a real business cycle model with financial frictions, calibrated for the 2003-2017 period. Our work explored the underlying investment model in our general equilibrium framework to investigate the effects of economic uncertainty – emerging from a large number of competitive agents – in capital accumulation.

We draw a number of conclusions from our research: First, *agency costs strongly impact our model economy*. As in other general equilibrium models, they work like capital adjustment costs: asymmetric

Figure 9 – Welfare, agency costs and microeconomic uncertainty shocks



Source: The author.

information between lenders and borrowers increase the cost of external finance, with uncertainty shocks affecting bankruptcy rates and the supply of capital. Second, *microeconomic uncertainty shocks impacts intertemporal choice and capital accumulation*. Analyzing the responses from uncertainty shocks impulses, we found that uncertainty negatively impacts investment, as expected from the literature discussion. A broad literature points out that this effect would be amplified in economies with greater credit constraints. Also, in more uncertain times agents cease to invest and engage in present consumption. Third, *microeconomic uncertainty shocks are welfare reducing*, as the steady state levels of household consumption of final goods are decreasing in uncertainty.

The key findings of this work suggest that authorities should pursue policies that minimize agency costs in the capital market. As an example, a further development of credit scores by financial intermediaries.

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